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INVESTOR IN PEOPLE

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Claims searched:	1 to 6	**Date of search:**	8 October 1999

Patents Act 1977
Amended Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): G1N (NAGA10, NAGB10, NAGC10, NAGD10), F2V (VW12, VW13, VW14)

Int Cl (Ed.6): G01B (7/00, 7/14), G01D5/20, F02M65/00

Other: Online: EPODOC; WPI; PAJ

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 0656475 A1	(HOFMANN et al) - see abstract & fig.1	1
Y	EP 0431975 A1	(BARRIE CHARLES) - see col.2 lin.22 to 28	3,4
X Y	EP 0392379 A2	(MARIO) - see col.3 lin.9 to 13, lin.30 to 45	X (1,2) Y (3,4)
X	WO 89/07746 A1	(GARSHELIS) - see p.4 last 2 paragraphs	1
X	US 5442865	(WALLRAFEN) - see col.1 lin.40 to 54	1
X	US 4403515	(IWASAKI) - see col.4 lin.60 to col.5 lin.27	1,2
X	US 4397180	(WOLFF et al) - see col.5 lin.25 to 36	1
X	US 3956973	(POMPLAS) - see col.3 lin.26 to 52	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

CLAIMS

1. A needle lift sensor for monitoring movement of a valve needle, the lift sensor comprising a moveable member carried by and moveable with the valve needle, and a sensor arranged to monitor movement of the moveable member in a location spaced from the axis of sliding movement of the valve needle.

2. A lift sensor as claimed in Claim 1, wherein the sensor comprises an inductive displacement transducer.

3. A lift sensor as claimed in Claim 1, wherein the moveable member is arranged to carry a probe, the sensor comprising a coil into which the probe extends, movement of the needle causing movement of the probe thus varying the inductance of the coil.

4. A lift sensor as claimed in Claim 3, wherein the coil is wound upon a micro-bobbin.

5. A lift sensor as claimed in Claim 4, wherein the micro-bobbin is of dimensions such that the application of fuel under high pressure thereto urges the micro-bobbin into sealing engagement with an adapter plate within which the sensor is located.

6. A needle lift sensor substantially as hereinbefore described with reference to the accompanying drawings.

resulting in the enlarged diameter end 44a of the bobbin 44 being urged into sealing engagement with the shoulder 20c thus restricting or preventing leakage of fuel from the control chamber 20 past the micro-bobbin 44, in use.

It will be appreciated that as the probe 42 simply slides within the opening formed in the micro-bobbin 44, but not does engage the micro-bobbin 44, no additional frictional forces are applied to the needle 10, thus movement of the needle 10, in use, is not impaired.

The provision of such a needle lift sensor permits the position of the needle to be monitored, either during testing or calibration of the injection prior to use, or during use to provide a signal which is input to the controller of the fuel injector for use in controlling the operation of the injector.

extending arm 40b. The hub 40a is located within the chamber 20, the arm 40b extending from the chamber 20 along a narrow channel 20a which communicates with the chamber 20, the channel 20a opening into a blind bore 20b which extends parallel to the axis of the bore defining the chamber 20. The outer end of the arm 40b carries a probe 42 in the form of a short length of small diameter magnetic material, for example a 2mm length of 0.3mm diameter spring steel. The probe 42 extends in a direction parallel to but spaced from the axis of the needle 10. The probe 42 extends into a blind opening formed in a micro-bobbin 44 which carries a sensor winding 46, the bobbin 44 and winding 46 being located within the bore 20b. The bobbin 44 is conveniently constructed from Torlon or a suitable ceramic material or any alternative suitable insulating material. The outer diameter of the bobbin 44 and winding 46 is conveniently approximately 1.9mm. The ends of the wire forming the winding 46 extends through openings formed in the micro-bobbin 44 and are connected to an appropriate apparatus to allow measurement of the inductance of the winding. It will be appreciated that as the spring steel probe 44 moves, the length of the probe 42 located within the winding 46 changes, thus varying the inductance of the winding, thus the measurements of the inductance of the winding 46 can be used to monitor movement of the needle 10 and to provide an indication as to the axial position of the needle 10.

The lower end region 44a of the bobbin 44 is of increased diameter and is engageable upon a shoulder 20c defined part way along the bore 20b formed in the distance piece 18 within which the micro-bobbin 44 is located. The enlarged diameter end of the bobbin 44 is exposed to the fuel pressure within the chamber 20, thus if the fuel pressure within the chamber 20 is high, then a large force is applied to the micro-bobbin 44

continued flow of fuel at a restricted rate through the passage 24 commences pressurization of the fuel within the control chamber 20.

When injection is to be terminated, the actuator is de-energized and the valve member 28 returns into engagement with its seating under the action of the spring. Such movement breaks the communication between the passage 32 and the low pressure drain, and the flow of fuel at a restricted rate through the passages 38, 32 increases the pressure acting upon the end surface of the needle 10, and a point will be reached beyond which the fuel pressure acting upon the needle 10 in conjunction with the action of the spring 22 and the fuel pressure within the control chamber 20 is sufficient to return the needle 10 into engagement with its seating, thus terminating injection.

The arrangement illustrated in Figure 2 differs from that of Figure 1 in that the fuel pressure within the chamber 20 is low, the chamber 20 communicating with a low pressure drain through an appropriate passage (not shown). Injection is controlled by controlling the fuel pressure applied to the bore 12, injection occurring when the fuel pressure applied to the bore 12 is sufficient to lift the needle 10 against the action of the spring 22. Injection terminates when the fuel pressure applied to the bore 12 is allowed to fall to a level sufficiently low to allow the needle 10 to move under the action of the spring 22 to return the needle into engagement with its seating.

The injectors described with reference to Figures 1 and 2 both include a needle lift sensor comprising a moveable support member 40 engaged between the spring 22 and the needle 10. The support member 40 includes an annular hub 40a which is integral with an outwardly

In use, fuel under high pressure is supplied to the passage 16 from the common rail, thus the bore 12 is charged to a high pressure. The fuel within the bore 12 acts upon angled thrust surfaces 10a of the needle 10, applying a force to the needle 10 urging the needle 10 away from the seating. This force is countered by the action of the spring 22 and the action of the fuel under pressure within the control chamber 20 acting upon the upper end surface of the needle 10. While the fuel pressure within the control chamber 20 is high, the forces urging the needle into engagement with its seating are sufficient to overcome the action of the fuel under pressure upon the thrust surfaces 10a, thus the valve needle 10 remains in engagement with its seating. Fuel injection is therefore not taking place.

In order to commence injection, the actuator is energized to cause the valve member 28 to lift away from its seating. As a result, fuel is able to escape from the control chamber 20 at a restricted rate to the low pressure drain reservoir thus the fuel pressure acting upon the needle 10 urging the needle 10 towards its seating is reduced. The diameters of the restrictions in the passages 24, 32 are chosen to ensure that the rate at which fuel flows from the control chamber 20 exceeds the rate at which fuel is supplied to the control chamber 20. The reduction in the pressure within the control chamber 20 allows the needle 10 to lift away from its seating, thus fuel is able to flow past the seating and is delivered through the outlet openings of the nozzle body 14. During injection, the presence of the restricted region 16a in the passage 16 limits the rate at which fuel is supplied to the bore 12, thus the fuel pressure acting upon the thrust surfaces 10a reduces. Further, when the valve needle 10 reaches its fully lifted position, the upper end thereof engages the blind end of the bore defining the control chamber 20 closing the passage 32. As a result, the

The passage 16 includes a restriction 16a which limits the rate at which fuel can flow to the bore 12, in use.

The nozzle body 14 abuts a distance piece 18 which includes a blind bore defining, with the nozzle body 14, a control chamber 20. A spring 22 is located within the control chamber 20, the spring 22 being arranged to apply a force to the needle 10 urging the needle 10 into engagement with its seating. A passage 24 including a region of small diameter provides a restricted flow path between the passage 16 and the control chamber 20.

The distance piece 18 abuts a valve housing 23 which includes a through bore within which a control valve member 28 is slidable. The valve member 28 includes a region engageable with a seating to control communication between a passage 30 which communicates through a passage 32 provided in the distance piece 18 with the control chamber 20, and a chamber 34 which communicates through passages (not shown) with a low pressure drain reservoir. The valve member 28 is biased by means of a spring (not shown) towards the position illustrated in which such communication is not permitted. The valve member 28 carries an armature 36 which is moveable under the influence of a magnetic field generated, in use, by an electromagnetic actuator (not shown) to lift the valve member 28 away from its seating, to permit such communication to occur.

As illustrated, the passage 32 includes a region of small diameter, thus the rate at which fuel is permitted to flow from the control chamber, in use, is restricted. A further passage 38 is provided in the distance piece 18 providing a restricted flow path from the passage 16 to the passage 32.

The coil is preferably wound upon a micro-bobbin. The coil is therefore of small diameter. The micro-bobbin is conveniently of dimensions such that the application of fuel under high pressure thereto urges the micro-bobbin into sealing engagement with an adapter plate within which the sensor is located.

It will be appreciated that such an arrangement is compact and is designed to withstand high pressures without leaking to an unacceptably high degree. The arrangement is therefore suitable for use in an injector for use in a common rail fuel system, but it will be appreciated that the needle lift sensor may be used in other types of injector.

The invention will further be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a sectional view of part of a fuel injector incorporating the needle lift sensor of an embodiment of the invention; and

Figure 2 is a view, in greater detail, illustrating the sensor in use in an alternative injector.

Figure 1 illustrates a fuel injector which comprises a valve needle 10 slidable within a blind bore 12 formed in a nozzle body 14. The blind bore 12 defines, adjacent its blind end, a seating with which the needle 10 is engageable to control the flow of fuel from the bore 12 to a plurality of outlet openings located downstream of the seating. The bore 12 communicates through a supply passage 16 with a common rail charged with fuel to a high pressure by an appropriate high pressure fuel pump.

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NEEDLE LIFT SENSOR

This invention relates to a sensor for monitoring the position of the valve needle of a fuel injector.

It is known to mount a needle lift sensor upon the valve needle of a fuel injector, the sensor extending coaxially with the needle, to permit the position of the needle to be sensed. In such an arrangement, the presence of the sensor results in the injector being of relatively large dimensions. Further, where used in a common rail type system in which the sensor is exposed to very high fuel pressures, for example 2000 bar or more, unacceptably high levels of fuel leakage occur as the sensors are not designed for use in such applications.

It is an object of the invention to provide a needle lift sensor which is of relatively compact form and is suitable for use in applications in which the sensor may be subject to high pressures.

According to the present invention there is provided a needle lift sensor for monitoring movement of a valve needle, the lift sensor comprising a moveable member carried by and moveable with the valve needle, and a sensor arranged to monitor movement of the moveable member in a location spaced from the axis of sliding movement of the valve needle.

The sensor conveniently comprises an inductive displacement transducer.

The moveable member is preferably arranged to carry a probe, the sensor comprising a coil into which the probe extends, movement of the needle causing movement of the probe thus varying the inductance of the coil.

FIG 1

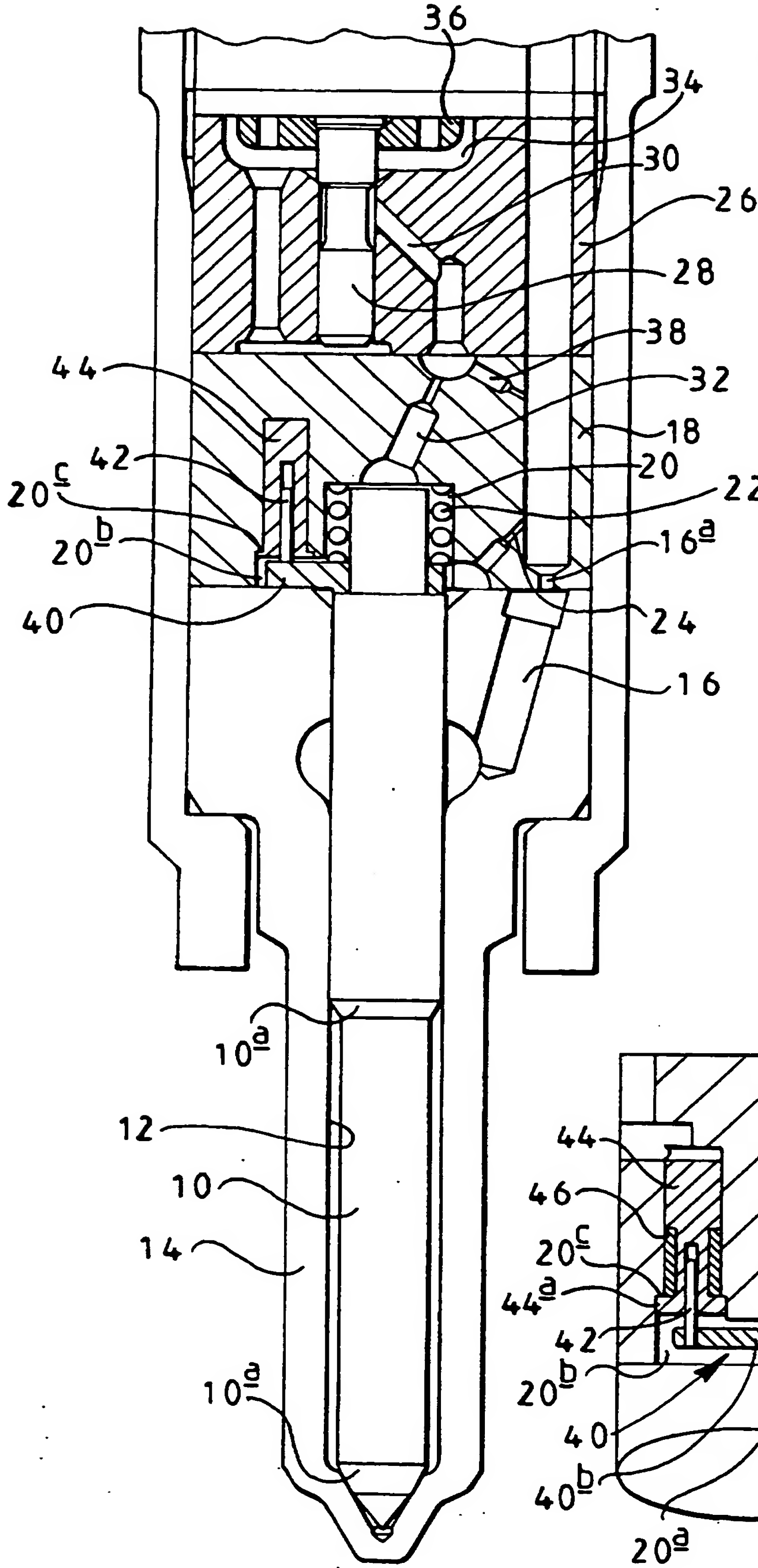
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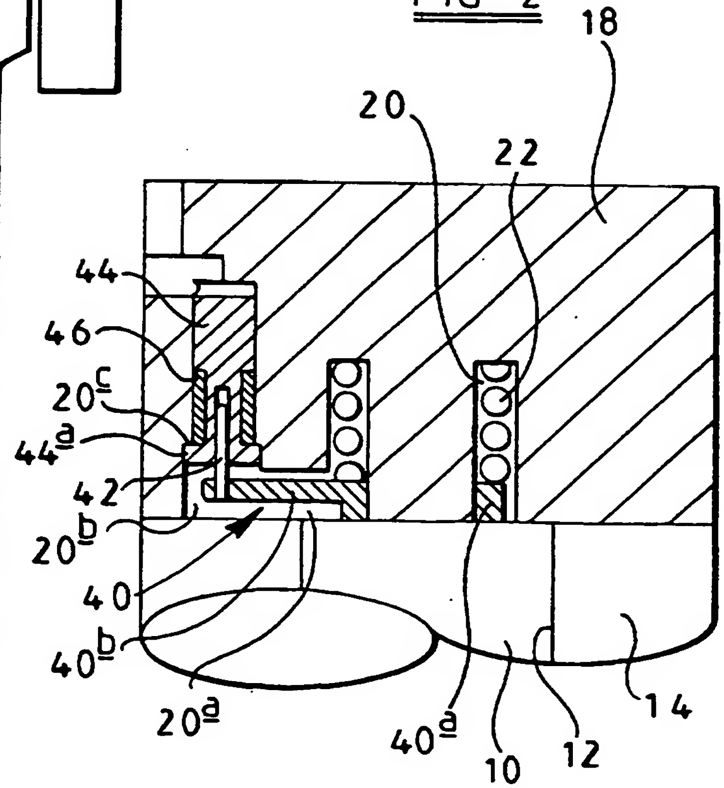
FIG 2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WO 89/07746 A1 US 5442865 A US 4403515 A
US 4397180 A US 3956973 A

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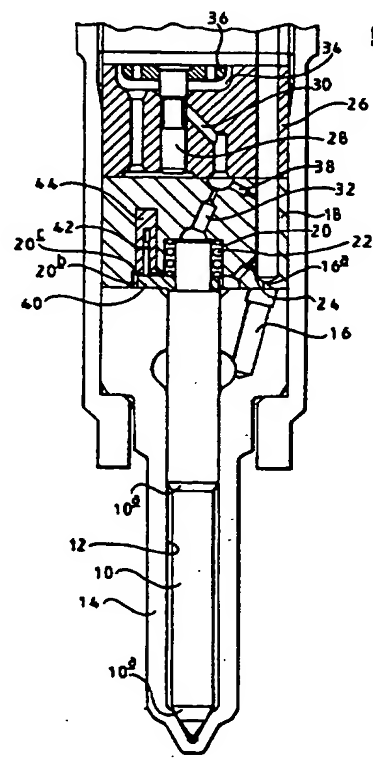
(54) Abstract Title
Needle lift sensor

(57) A valve needle sensor assembly for monitoring the position of a valve needle (10). A probe (42) is rigidly attached to the valve needle (10) via a support member (40). As the needle slides within the blind bore (12) along a fixed axis, the steel probe (42) located away from this fixed axis moves within a bobbin (44) containing sensor coil windings (46). The inductance of the coil (46) changes as the probe (42) moves within it so the inductance can be used to indicate the axial position of the needle (10).

FIG 1



At least one drawing originally filed was informal and the print reproduced here is taken fr m a later filed formal c py.

The claims were fil d later than the filing dat but within the period prescribed by Rule 25(1) f the Patents Rules 1995.

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